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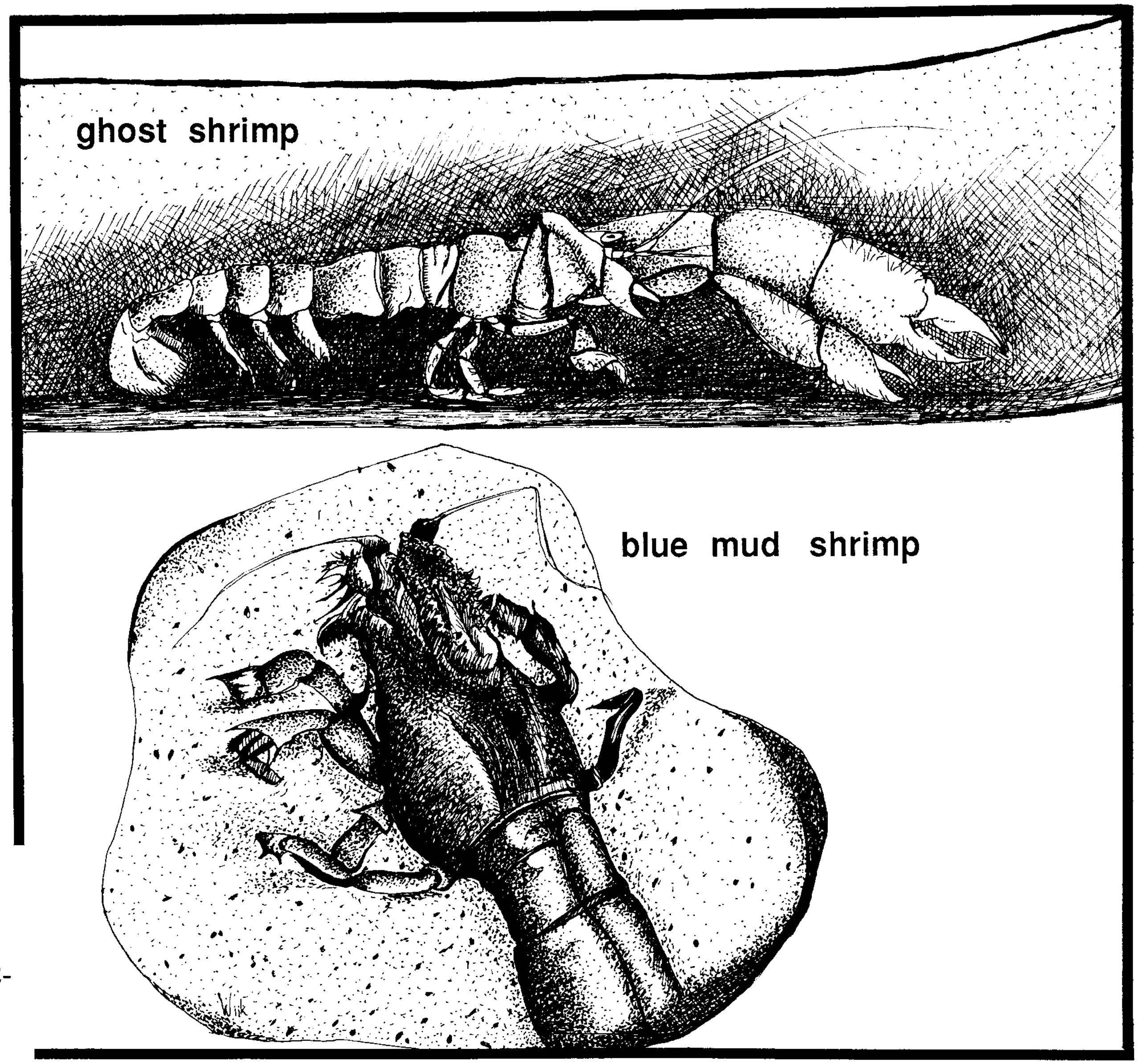
January 1989

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

GHOST SHRIMP AND BLUE MUD SHRIMP



Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

GHOST SHRIMP AND BLUE MUD SHRIMP

by

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

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GHOST SHRIMP AND BLUE MUD SHRIMP

NOMENCLATURE/TAXONOMY/RANGE

Scientific name .... *Callianassa californiensis* Dana
Preferred common name ... Ghost shrimp (Figure 1)
Scientific name .... *Upogebia pugettensis* (Dana)
Preferred common name .... Blue mud shrimp (Figure 2)

Other common names ..... Crawfish, mud prawns, ghost shrimp (collectively), burrowing shrimp (Stevens 1928); red ghost shrimp (*C. californiensis*; Phillips 1984); orange mud shrimp (*C. californiensis*; MacGinitie 1935); mud shrimp (*U. pugettensis*; Hedgpeth 1970).
Class .... Crustacea
Order .... Decapoda
Family .... Callianassidae

Geographic range: The ghost shrimp is found in intertidal areas along the west coast of North America from Mutiny Bay, Alaska, to the mouth of the Tijuana River, San Diego County, California; MacGinitie (1934) and Ricketts and Calvin (1968) reported finding specimens as far south as El Estuario de Punto Banda, Baja California Norte, Mexico. The blue mud shrimp is found from southeastern Alaska to San Quentin Bay (Bahia de San Quentin) in Baja California Norte. The general distribution of the two species in the Pacific Northwest is identical (Figure 3).

MORPHOLOGY AND IDENTIFICATION AIDS

The head and thorax of the ghost and blue mud shrimps are united into a cephalothorax. Like that of other arthropods, this cephalothorax is covered by a carapace or exoskeleton of hard, chitinous material that is shed (molted) periodically to allow for growth. The gills are located in special chambers at the sides of the thorax under the carapace. The blue mud shrimp has a large rostrum (forward extension of the carapace) and cylindrical eye stalks; the ghost shrimp has no rostrum or a small one and flattened eye stalks. Both have external mouthparts (maxillipeds) and antennae. Hair-like structures cover much of the shrimps' bodies and serve such functions as receiving sensory stimuli, obtaining food, cleaning self, creating water currents, and cleaning and carrying eggs (MacGinitie 1934).

Both shrimps have five pairs of thoracic legs (periopoda). The first pair of legs may be slightly unequal and only somewhat pincerlike (subchelate), and the rest, simple as in the blue mud shrimp; or, the first pair may be very unequal and very pincerlike (chelate), the second pair also pincerlike, and the fifth pair somewhat pincerlike as in the ghost shrimp (Schmitt 1921). The asymmetry of the first pair of legs characteristic of the ghost shrimp is more pronounced in males, and the larger cheliped (pincer leg) may be on either the left or the right side (MacGinitie 1934).

Both shrimps have five pairs of leaflike abdominal appendages (pleopods) or swimmerets. They also have flattened tail appendages (uropods) adapted for swimming. The blue mud shrimp has a short, square telson

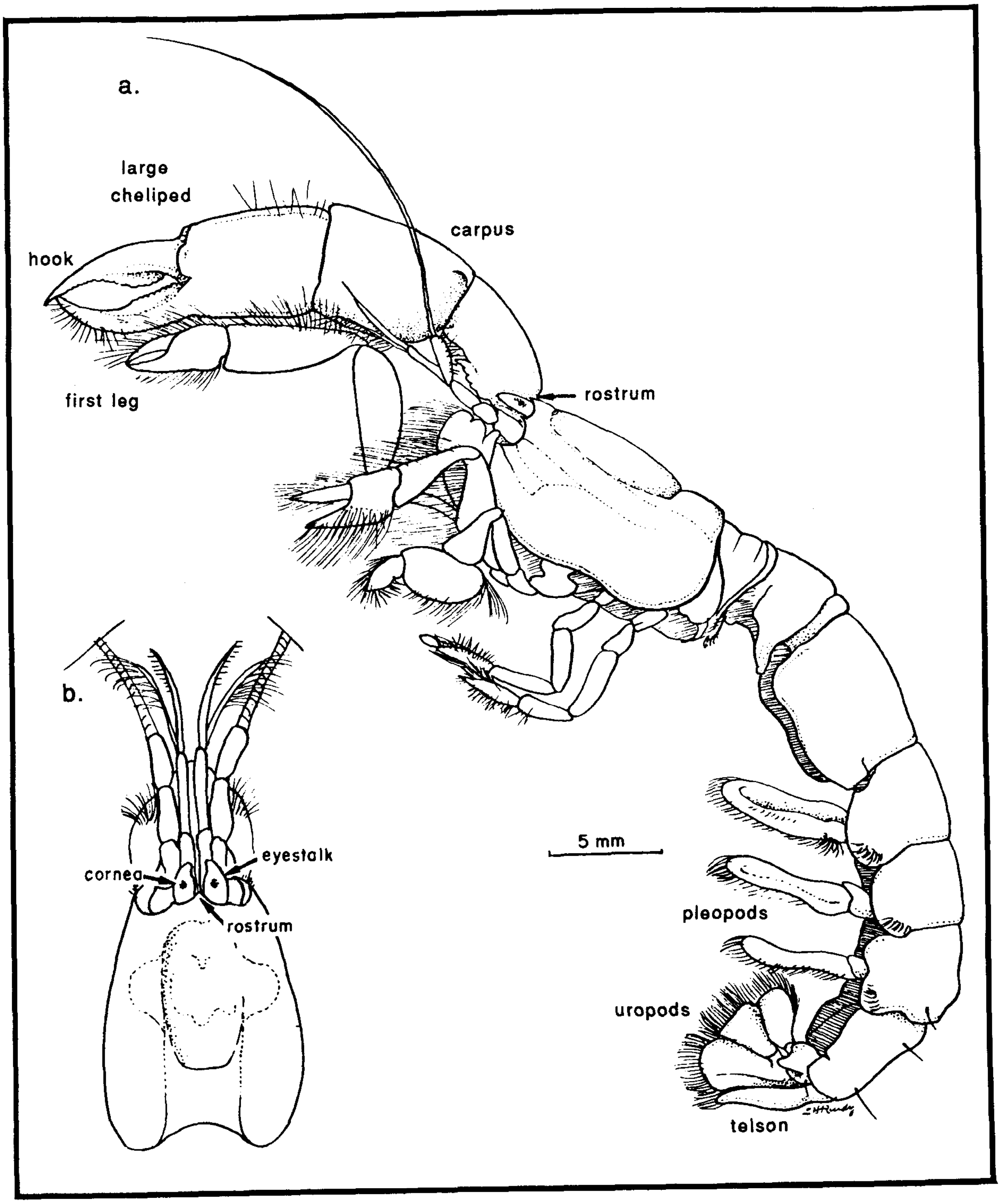

Figure 1. Ghost shrimp male (a) showing morphology of leg pairs (actual total length of specimen from rostrum to telson is 5 cm (2 inches)) and (b) enlargement of head area (dorsal view). Reproduced with permission from Rudy and Rudy 1983 (copyright Paul and Lynn Rudy).

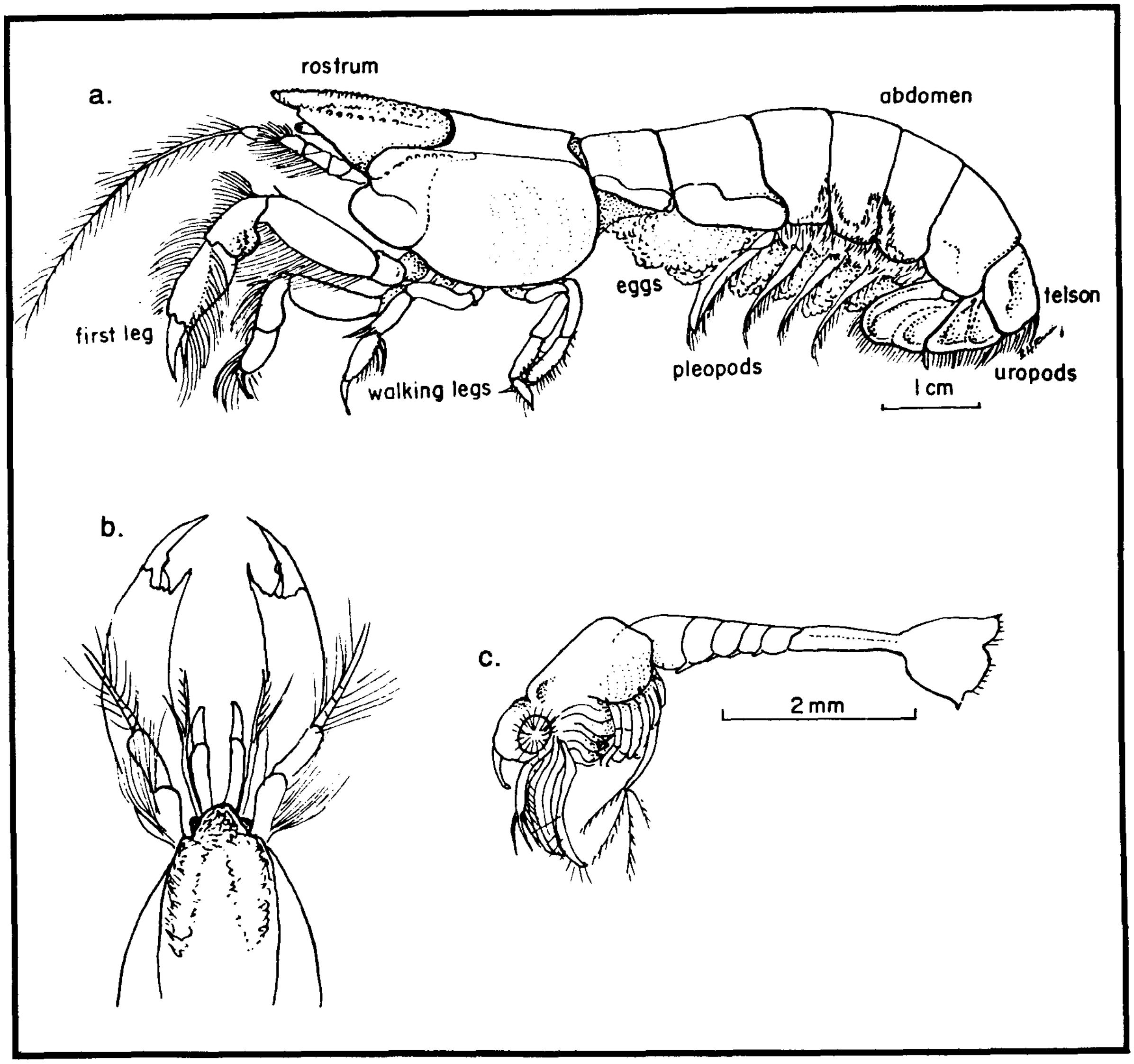

Figure 2. Ovigerous blue mud shrimp female (a) actual length from rostrum to telson (9 cm; 3.5 inches), (b) enlarged dorsal view of head, and (c) first-stage larval form (actual total length about 5 mm (0.2 inches)). Reproduced with permission from Rudy and Rudy 1983 (copyright Paul and Lynn Rudy).

(terminal segment); the ghost shrimp has a longer, more pointed one.

These two shrimps can be distinguished from each other on the basis of the differences in the first pair of legs and color. The blue mud shrimp is usually dirty blue-green and the ghost shrimp varies from white to pink, red, and orange. The carapace of the ghost shrimp is often transparent enough to allow observation of its internal organs (Johnson and Snook 1955), making it an interesting study specimen. There are other Callianassa species besides the ghost shrimp on the west coast; however, only one, C. gigas, is similar

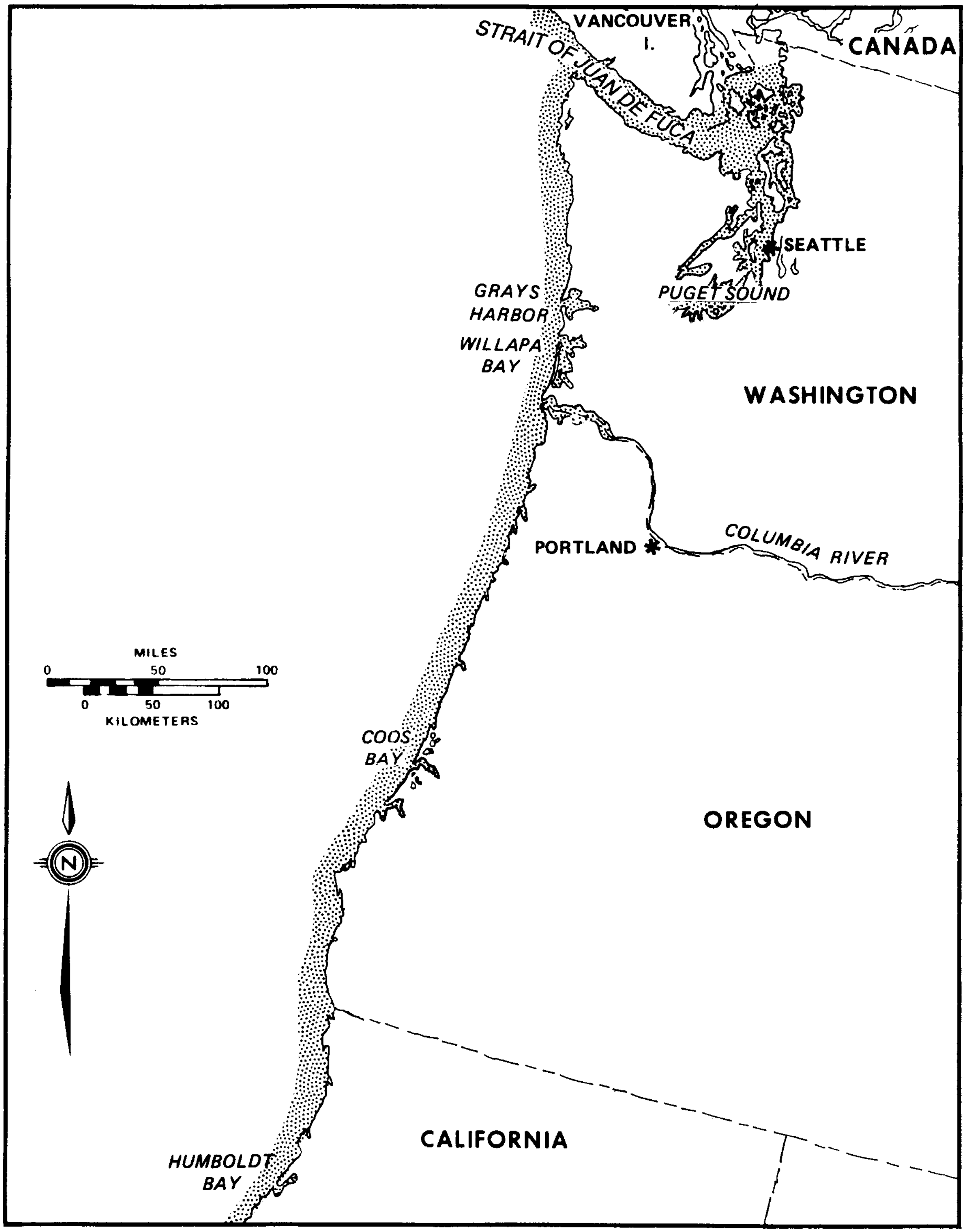

Figure 3. Map showing geographic distribution of ghost shrimp and blue mud shrimp in Pacific Northwest region in intertidal sand or mudflats of west coast bays and estuaries.

in distribution, habitat, and habits. Callianassa gigas is larger than the ghost shrimp (125-150 mm (5-6 inches) long). And although the females and juveniles of these two species are similar in appearance, the large cheliped of the C. gigas male is longer and narrower than that of the male ghost shrimp (Morris et al. 1980).

REASONS FOR INCLUSION IN THE SERIES

Although the ghost shrimp and blue mud shrimp are harvested as bait along the entire west coast of the United States, they are considered by some to be important pests of commercial oyster-growing operations in the Pacific Northwest (Ricketts and Calvin 1968; McCrow 1972; Buchanan et al. 1985). They are believed to destabilize the substrate, smother oysters with debris, and drain off water (through their burrows) from diked oyster beds.

Either species can alter the physical characteristics of the habitat it occupies and affect the composition of the intertidal infaunal community (Brenchley 1981; Posey 1986a). The ghost shrimp (Figure 1) is the more active burrower of the two and more severely affects substrate consistency (Bird 1982). Both the blue mud shrimp (Figure 2) and the ghost shrimp are associated with a variety of commensal and parasitic species (MacGinitie 1930, 1934, 1935; MacGinitie and MacGinitie 1968; Rickets and Calvin 1968; Kozloff 1973). The ghost shrimp is one of the most abundant residents of marine sloughs or bay mudflats on the west coast of North America (MacGinitie 1934).

LIFE HISTORY

Both the ghost shrimp and the blue mud shrimp live in burrows in the intertidal sand or mudflats of west coast bays and estuaries. Entrances to ghost shrimp burrows may be observed in the center of small conical hills of sand and small pebbles; those of the blue mud shrimp are less conspicuous, with much smaller, or absent, surrounding hills of sand (Kozloff 1973).

Members of the blue mud shrimp species nearly always live in male-and-female pairs; each pair inhabits a smooth-walled, permanent, branching burrow extending about 45 cm (18 inches) below the surface. The burrow generally has several entrances, each about 1 cm (0.4 inches) in diameter. The diameter of the tunnel beyond the opening is too narrow to allow the shrimp to turn around; consequently, specially enlarged chambers are required. The smooth walls appear to be cemented with a secretion produced by the shrimp. The blue mud shrimp forms a "mud basket," with its first two pairs of legs, which it uses as a scoop to transport mud and build its burrow, and as a strainer to collect food. The third and fifth pairs of legs are used for walking, and the fourth pair is braced against the burrow walls. The tail-fan can be used to block the burrow tunnel so effectively that the flow of water is stopped; this may possibly be a protective maneuver to ward off attacks from the rear (MacGinitie 1934). The species feeds on detritus and plankton strained from seawater, which it forces through the burrow by using its four pairs of swimmerets (pleopods) (MacGinitie 1930).

The ghost shrimp also inhabits burrows, but of a less permanent character since this species sifts most of its food directly from the substrate and tunnels almost constantly, reworking the sediment to a depth of about 75 cm (30 inches) in search of food. Burrow structures of ghost shrimp are less consistent in pattern than those of blue mud shrimp; the ghost shrimp digs tunnels branching in all directions, forming complex burrows with various numbers of openings (MacGinitie 1934). The second and third pairs of legs are used for digging and the fourth and fifth for cleaning its appendages, gills, and back, and for cleaning and manipulating its eggs (MacGinitie 1934). The third, fourth, and fifth pairs of legs are used in walking; the fourth pair is extended outward against the burrow wall for support. The swimmerets of the ghost shrimp constantly circulate water through the burrow, facilitating respiration. Its tail-fan, like the blue mud shrimp's, can be used (probably protectively) to block the burrow. The large cheliped of the male is a weapon used in disputes over territory and during the mating season (MacGinitie 1934).

Development of Eggs and Larvae

Female ghost shrimp are ovigerous (capable of producing fertile eggs) throughout the year, but the principal spawning season is in late June and early July (MacGinitie 1935). Intensive breeding probably begins in spring, but ovigerous females may still be plentiful as late as August. Spring warming appears to be the trigger for egg development. Three to four broods are produced at about 6-week intervals. The larvae develop as plankton in coastal waters through five zoeal stages, which are distinguishable from one another primarily on the basis of size (McCrow 1972). A total of 6-8 weeks is spent as nearshore oceanic plankton (through the five zoeal and one megalopal stage); zoeal larvae are usually released on ebb tides in June and July, and the first megalopae appear in early August. Recruitment to the estuary is probably facilitated by flood tides occurring in late summer and fall. Larval drifting during this planktonic phase very likely serves as a mechanism of genetic exchange among populations in different estuaries (Johnson and Gonor 1982).

Blue mud shrimp females are known to be ovigerous in January, February, and part of March (MacGinitie 1935), but larval development of this species has not been studied extensively.

Postlarval Development

Juvenile ghost shrimp are presumed to metamorphose rapidly to a state adapted for life on the bottom just before recruitment to the estuary (Johnson and Gonor 1982). Mortality due to predation is probably substantial during the short period (minutes to hours) between the moment the organism drops to the substrate and its successful burrowing beneath the surface (MacGinitie 1934). The lifespan of the ghost shrimp has been variously estimated at 3-5 years (Bird 1982), 10 years (MacGinitie 1935), and 15-16 years (Ricketts and Calvin 1968). The blue mud shrimp is also believed to be relatively long-lived (MacGinitie 1930).

Habitat

Both of these species are commonly found in intertidal areas of mixed sand and mud. The blue mud shrimp lives in muddier areas than does the ghost shrimp; observations with respect to tidal height preferences vary (Table 1). In Oregon estuaries, ghost shrimp were consistently found in tideflats closer to the ocean than were blue mud shrimp (Bird 1982). Both species are common residents of eelgrass beds in the Pacific Northwest (Phillips 1984).

GROWTH CHARACTERISTICS

Typically, length of adults is 5-10 cm (2-4 inches) in the ghost shrimp and 7.5-10 cm (3-4 inches) in the blue mud shrimp (MacGinitie and MacGinitie 1968). However, length may reach 11.5 cm (4.5 inches) in the ghost shrimp and 15 cm (6 inches) in the blue mud shrimp (Morris et al. 1980). MacGinitie (1930, 1935)

Table 1. Habitat preferences of ghost shrimp and blue mud shrimp reported at different locations.

Location	Ghost shrimp	Blue mud shrimp	Source
Pacific NW	Muddy sand	Muddier sand	Kozloff 1973
Yaquina Bay, OR	0 to 1 ft	0 to 1 ft	Thompson and Pritchard 1969
Oregon estuaries	Tideflats close to ocean	Tideflats further from ocean	Bird 1982
N. California	Sandier mid-tidal areas	Lower, muddier flats	Hedgpeth 1970
Tomales Bay & Elkhorn Slough, CA	Muddy sand	Softer mud	Smith and Carlton 1975
Monterey Bay, CA	Generally lower tidal areas; mixed sand and mud	Generally higher tidal areas; mud, sandy mud with clay	MacGinitie 1935

reported finding the largest blue mud shrimp in the muddiest, least rocky areas.

Ghost shrimp mature at 18-24 months and some reproductive females may be less than 3 cm (1.2 inches) long; blue mud shrimp take 3 or more years to mature and reproductive females exceed 6 cm (2.4 inches) in length. Estimated growth in length averages approximately 15-30 mm/yr (0.6-1.2 inches/yr) in ghost shrimp and 18-26 mm/yr (0.7-1.0 inches/yr) in blue mud shrimp (Bird 1982). Density within a ghost shrimp colony and the colony's location appear to influence both growth and size at sexual maturity; ghost shrimp in the less dense colonies closest to the ocean grow faster, and the females become sexually mature at larger sizes and produce more and larger eggs (Bird 1982).

Densities of ghost shrimp have been estimated at 700-1,400/m^2 (2.8-5.6 million/acre) in Yaquina Bay, Oregon (McCrow 1972); 420-770/m^2 (1.7-3.1 million/acre) in high-density areas of Sand Lake Estuary, Oregon; and less than 300/m^2 (1.2 million/acre) in other areas on the Oregon coast (Bird 1982). Blue mud shrimp densities in Oregon estuaries range from 330 to 660/m^2 (1.3-2.7 million/acre) (Bird 1982). Biomass of either species sometimes exceeds 2.0 kg/m^2 (18,000 lb/acre (wet weight)).

THE FISHERY

Ghost and blue mud shrimp are harvested by commercial bait fishermen and recreational fishermen in California, Oregon, and Washington. Peterson (1977) described a method used in southern California in which water is pumped into the substrate under pressure, forcing the animals out of their burrows; in the area he studied, harvest noticeably reduced the ghost shrimp population. In the Pacific Northwest, attempts have been made to control the shrimp on commercial Japanese oyster (Crassostrea gigas) grounds with the insecticide Sevin (carbaryl). This pesticide has been used to control ghost and mud shrimp in Washington since 1963 (Washington Department of Fisheries and Washington Department of Ecology 1985), and although it has been used on oyster grounds in Oregon, such use is currently unlawful there (L. Fredd, Oregon Department of Fish and Wildlife, Portland, OR; pers. comm.). During its use in Oregon, bait fishermen noted ghost shrimp mortalities in untreated areas soon after nearby oyster grounds were sprayed (Buchanan et al. 1985).

Washington oyster growers estimate that oyster production would drop 70%-80%, resulting in a $5 million annual loss in Pacific and Grays Harbor Counties, without ghost shrimp control (Washington Department of Fisheries and Washington Department of Ecology 1985). However, questions have been raised about the effects of Sevin on other organisms, including the commercially important Dungeness crab (Cancer magister), and on the estuarine ecosystem as a whole (Lindsay 1961; Stewart et al. 1967; Buchanan et al. 1985). Although the blue mud shrimp is believed to disturb the sediment far less extensively than the ghost shrimp (Bird 1982), both have been the objects of control programs.

ECOLOGICAL ROLE

Food and Feeding Habits

The ghost shrimp was once thought to feed exclusively by sifting organic detritus from the floor of its burrow through the hairs on the second and third pairs of legs, rejecting coarse material, and then ingesting the retained fine particles by the use of the maxillipeds (MacGinitie 1934). And although it is still thought to obtain most of its food in this manner, there is evidence that it also filters detritus and plankton from the water moving through its burrow as does the blue mud shrimp (Morris et al. 1980). Rejected material is deposited outside the burrow. Burrowing activity is heaviest in the upper 45-50 cm (18-20 inches), where the availability of food is greatest (MacGinitie 1934). The burrowing and feeding behavior of the ghost shrimp is vigorous enough to cause substantial alterations in surface sediment characteristics over time, decreasing organic content and shifting the particle size distribution upwards (Bird 1982). Sediment in dense ghost shrimp beds often has a soft, quicksand quality (Posey 1985). The burrowing activity of both the ghost and blue mud shrimp aerates the subsurface soil (MacGinitie 1930, 1934).

The blue mud shrimp is a suspension feeder, straining detrital particles and plankton from seawater kept moving through its burrow by the action of its swimmerets. To feed, the animal positions itself near a burrow entrance and increases the movement of the swimmerets to increase the current of seawater through the burrow. The third maxillipeds are used to periodically sweep the food particles collected into the animal's mouth. Particles that are too big are ejected (MacGinitie 1930).

Cooperation, Competition, and Predation

By aerating the subsurface sediment and digging burrows protected from most predators, ghost shrimp and blue mud shrimp provide an environment attractive to commensals. Commensal and parasitic species associated with these shrimp include a blind goby, three species of pea crabs, two species of clams, a copepod, a shrimp, polynoid worms, and isopods (see Table 2).

Species that might compete with these shrimp for either food or space

Table 2. Commensal (c) and parasitic (p) species reported in burrows of ghost shrimp and blue mud shrimp (compiled from MacGinitie and MacGinitie 1968; Ricketts and Calvin 1968; Kozloff 1973).

Species	Found with ghost shrimp	Found with blue mud shrimp
Goby		
Clevelandia ios (c)	In burrow	In burrow
Pea crabs		
Scleroplax granulata (c)	Abundant in burrow	Abundant in burrow
Pinnixa franciscana (c)	Abundant in burrow	---
P. schmitti (c)	In burrow (rare)	---
Clams		
Pseudopythina rugifera (c)	---	Underside of abdomen
Cryptomya californica (c)	Extends syphons into burrow	Extends syphons into burrow
Copepods		
Hemicyclops callianassae (c)	On gills	On gills
Clausidium vancouverense (c)	Underside carapace (common)	Under carapace
Shrimp		
Betaeus ensenadensis (c)	On gills	---
Polynoid worms		
Hesperonoe spp. (c)	In burrow	In burrow
Isopods		
(unidentified--p)	Under carapace	---
Phyllodurus abdominalis (p)	---	Underside of abdomen

are rare in ghost shrimp colonies because of the continual reworking of the sediment by this species. Infauna are both more varied and more abundant in blue mud shrimp colonies because this species less severely affects the sediment structure (Bird 1982).

Although ghost shrimp typically inhabit deep burrows, they are susceptible to predation by other animals because they sometimes venture outside their burrow entrances. Under test conditions, ghost shrimp spent over 25% of the time within 2 cm of the burrow entrance; the shrimp were also observed to move from one burrow to another and were often found with part of an appendage exposed above the surface (Posey 1985).

The seaward boundary of dense shrimp beds coincided with a fourfold seaward increase in the density of the major predator, the Pacific staghorn sculpin (*Leptocottus armatus*) in Coos Bay, Oregon (Posey 1986b). Caging experiments in Coos Bay indicated that predation by this fish, which was most intense in summer, probably restricts the seaward distribution of ghost shrimp (Posey 1986b).

Mud and ghost shrimps are sometimes killed by the leopard shark, Triakis semifasciata, and by the brown smooth-hound shark, Mustelus henlei. The leopard shark, whose range extends north to Oregon, apparently can shovel or burrow into the substrate to prey on benthic species (Russo 1975). Dungeness crabs are known to eat ghost shrimp, but the shrimp does not appear to be a major component of the crab's diet (Stevens et al. 1982; Posey 1985). Sea-run cutthroat trout (Salmo clarki clarki) also commonly eat ghost shrimp, but are not considered a major predator (Posey 1985). Posey also suggests that intertidally foraging birds may occasionally eat ghost shrimp.

ENVIRONMENTAL REQUIREMENTS

The optimal temperature range for ghost shrimp appears to be 10 to 13 °C, depending on depth below the surface. Egg-bearing females seem to prefer the cooler water at the greater depths; immature specimens are found higher up in the burrow. Water temperature in ghost shrimp habitat in Yaquina Bay, Oregon, varies seasonally from 9 to 15 °C (McCrow 1972). Activity of ghost shrimp decreased slightly with increasing maximum daily air temperature in an outdoor aquarium (Posey 1987).

Ghost shrimp tend to be most abundant at the seaward end of bays with substantial freshwater inflow (McCrow 1972) and tolerate salinities from about 25% to 125% the salinity of normal seawater (33 ppt). Blood salinity changes along with water salinity. In a laboratory test, salinities of 8-9 ppt were lethal to 75%-100% of ghost shrimp (Posey 1987). Activity of ghost shrimp decreased with decreasing salinity between 33 and 10 ppt (Posey 1987). The blue mud shrimp tolerates salinities as low as 10% that of seawater and regulates osmotically when salinity falls below 75% that of seawater (Morris et al. 1980).

Oxygen availability is no doubt a limiting factor for all intertidal species, including the ghost and blue mud shrimps (MacGinitie 1935). Thompson and Pritchard (1969) measured oxygen levels in burrows in Yaquina Bay, Oregon, and found that during ebb tide, oxygen levels were occasionally zero. They also found that under laboratory conditions, the ghost shrimp could survive anoxia (lack of oxygen) for 5.7 days and the blue mud shrimp could survive for 3.3 days, far longer than they would normally be subjected to anoxia in the environment.

Although the ghost shrimp has a lower normal metabolic rate and survives anoxia and hypoxia (low oxygen) better than does the blue mud shrimp, both appear to have respiratory adaptations that allow them to tolerate the low oxygen conditions under which they live. Laboratory experiments have shown that both species are able to lower their metabolic rates once oxygen levels become critically low. Additionally, studies of the ghost shrimp have demonstrated the following adaptations to hypoxia/anoxia: when oxygen levels become low, heart rate is lowered (Thompson and Pritchard 1969); a respiratory pigment, hemocyanin, liberates more bound oxygen to the tissues (Morris et al. 1980); and the shrimp is able to switch to an alternate, anaerobic metabolism (Pritchard and Eddy 1979; Morris et al. 1980).

Clifton et al. (1984) studied the effect of spilled oil on ghost shrimp colonies in Willapa Bay, Washington. They concluded that small amounts of oil carried in on the tides and temporarily stranded in intertidal areas are unlikely to have a serious long-term impact. However, stranded oil that is buried by a subsequent deposition of oil-free sediment creates a barrier to burrowing activity that can be expected to persist for years. They also concluded that the burrowing activity of the shrimp contributes to the introduction of oil into the sub-surface.

Although their effects on the environment are controversial in nature, the ghost and blue mud shrimp appear to be an integral part of the nearshore environments. And fortunately for the shrimp, their widespread distribution should allow them to sustain their populations despite the current attempts to eliminate them locally.

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. The profiles are prepared to assist in environmental impact assessments. The ghost shrimp (*Callianassa californiensis*) and blue mud shrimp (*Upogebia pugettensis*) are common residents of intertidal mudflats of the Pacific Northwest, as well as of the entire west coast of the contiguous United States. These species are decapod crustaceans, but not true shrimp. They are harvested as bait by recreational and commercial oyster-growing operations. Ghost shrimp larvae develop in summer in nearshore coastal waters and settle to the substrate surface, where they rapidly metamorphose; the life cycle of the blue mud shrimp is presumed to be similar. Both species spend their lives in burrows in the mudflat, where the ghost shrimp is primarily a deposit feeder and the blue mud shrimp is a suspension feeder.

17. Document Analysis a. Descriptors

Fishery	Salinity	Sediments	Predators
Growth	Temperature	Life Cycles	Competitors
Estuaries	Oxygen	Shrimps	Commensals
Feeding habits	Depth	Oil spills	

b. Identifiers/Open-Ended Terms

Ghost Shrimp *Callianassa californiensis* Dana

Blue Mud Shrimp *Upogebia pugettensis* (Dana)

c. COSATI Field/Group

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